CMOS 8-Bit Microcontroller

TMP87CS68DF

The TMP87CS68 is the high speed and high performance 8-bit single chip microcomputer. This MCU contains CPU core ROM, RAM, input/output ports, an A/D converter, four multi-function timer/counters, two serial interfaces (SIO and UART),and two clock generators on a chip. The 87CS68 provides high current output capability for LED direct drive.

Part No.	ROM	RAM	Package	OTP MCU
TMP87CS68DF	61184 bytes (60 kbyte-256 byte)	2 kbytes	P-LQFP80-1212-0.50A	TMP87PS68DF

Features

◆8-bit single chip microcomputer TLCS-870 series
◆ Instruction execution time: 0.5 μs (at 8 MHz, gear ratio 1/1)、
122 μs (at 32.768 kHz)
◆412 basic instructions
- Multiplication and Division (8 bits × 8 bits,16 bits ÷ 8 bits)
- Bit manipulations
(Set / Clear / Complement / Move / Test / Exclusive or)
- 16-bit data operations
- 1-byte jump/subroutine-call (Short relative jump / Vector call)

◆15 interrupt sources (External: 5, Internal: 10)
- All sources have independent latches each, and nested interrupt control is available.
- 3edge-selectable external interrupts with noise reject
- High-speed task switching by register bank changeover

◆10 Input/Output ports (72 pins)
- High current output: 7 pins (Typ. 20 mA)

◆Two 16-bit Timer/Counters
- Timer, Event counter, Programmable pulse generator output, Pulse width measurement, External trigger timer, Window modes

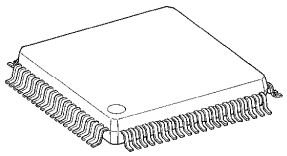
◆Two 8-bit Timer/Counters
- Timer, Event counter, Capture (Pulse width/duty measurement), PWM output, Programmable divider output modes

◆Time Base Timer (Interrupt frequency: 1 Hz to 16384 Hz)
◆Divider output function (frequency: 1 kHz to 8 kHz)
◆Watchdog Timer
◆8-bit Serial Interface
- With 8 bytes transmit/receive data buffer
- Internal/external serial clock, and 4/8-bit mode

◆8-bit successive approximate type A/D converter with sample and hold
- 8 analog inputs
- Conversion time: 23 μs / 92 μs (at 8 MHz, gear ratio 1/1)

◆Universal Asynchronous Receive and Transmitter (UART)
◆Dual clock operation
◆Internal clock select mode (fc, fc/2, fc/4, fc/8) Initial fc operation
◆Key on Wake-Up

P-LQFP80-1212-0.50A



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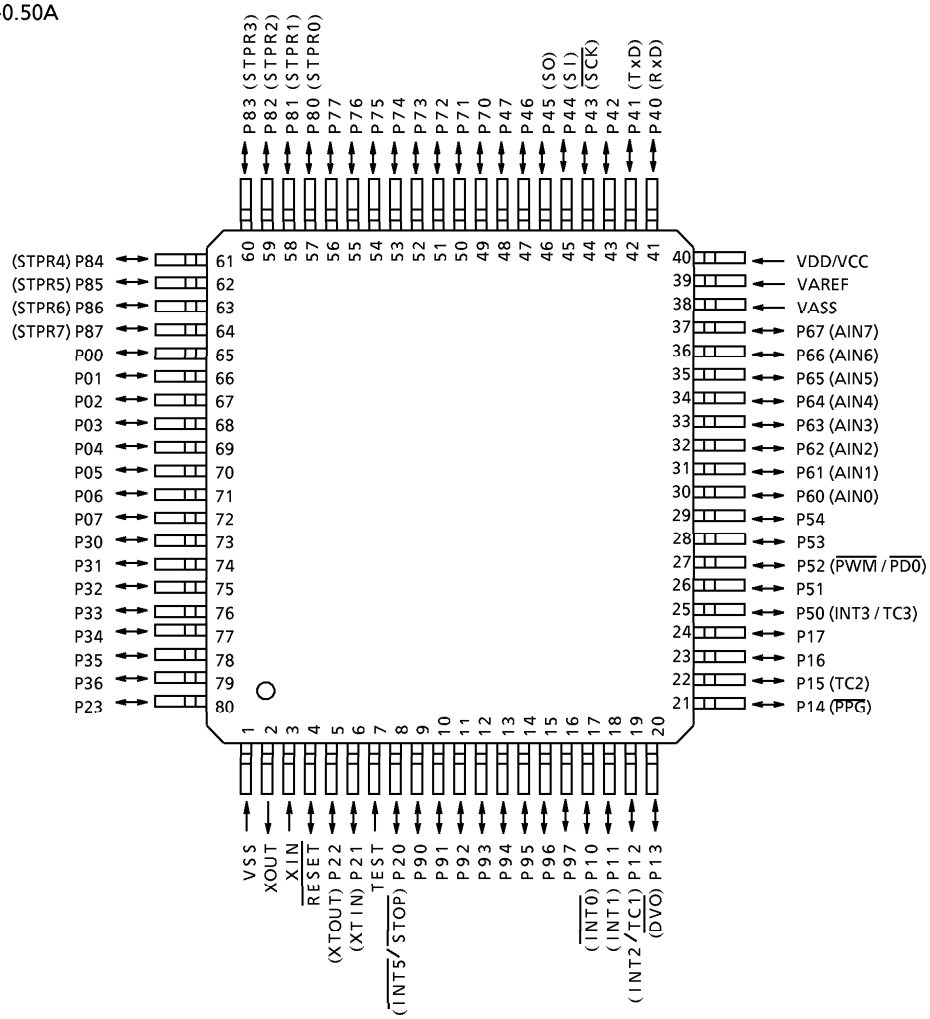
◆Five Power saving operating modes
- STOP mode: Oscillation stops. Battery/Capacitor back-up. Port output hold/high-impedance.
- SLOW mode: Low power consumption operation using low-frequency clock (32.768 kHz).
- IDLE1 mode: CPU stops, and Peripherals operate using high-frequency clock. Release by interrupts.
- IDLE2 mode: CPU stops, and Peripherals operate using high and low frequency clock. Release by interrupts.
- SLEEP mode: CPU stops, and Peripherals operate using low-frequency clock. Release by interrupts.

◆Wide operating voltage: 2.7 to 5.5 V at 4.19 MHz / 32.768 kHz
4.5 to 5.5 V at 8 MHz

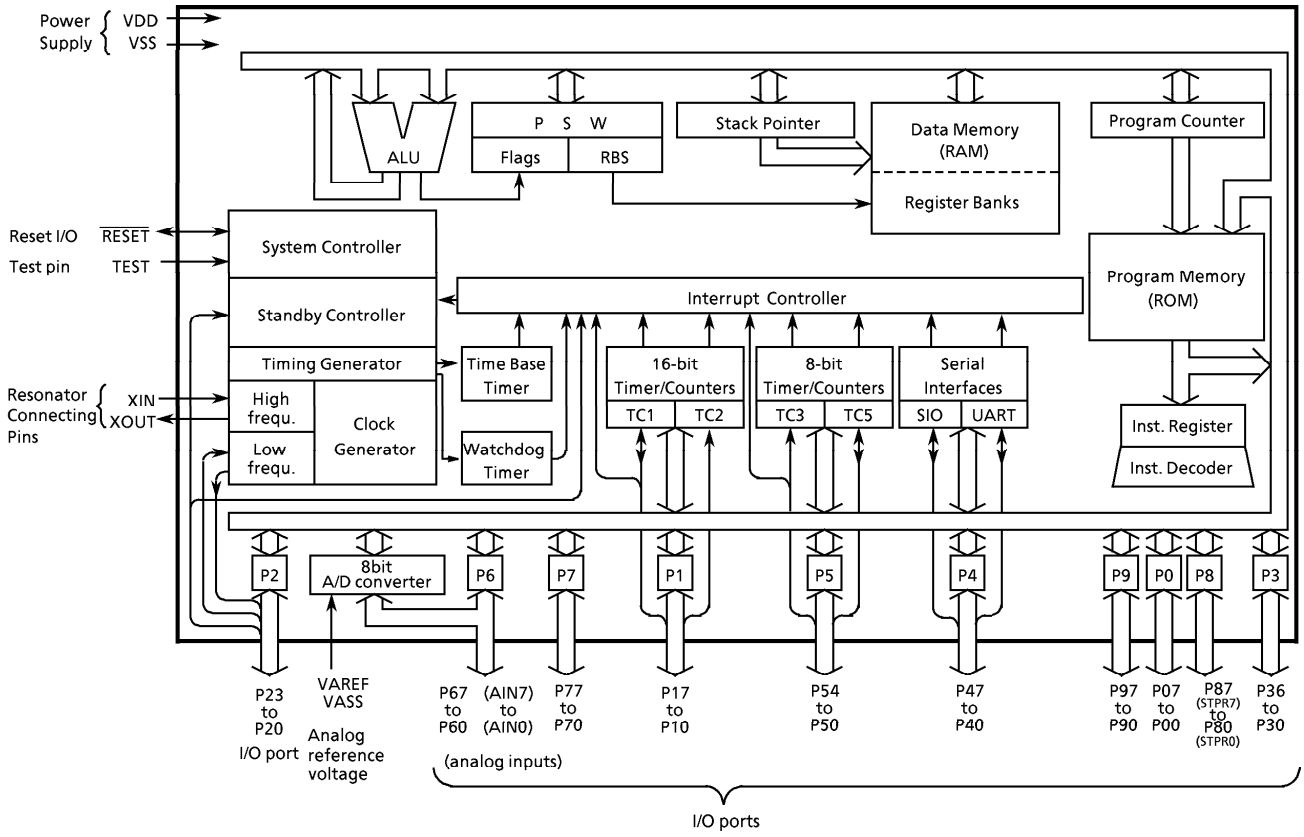
◆Emulation Pod:

Pin Assignments (Top View)

P-LQFP80-1212-0.50A



Block Diagram



PIN FUNCTION

PIN NAME	Input / Output	FUNCTION	
P07 to P00	I/O	Two 8-bit programmable input/output ports (tri-state). Each bit of these ports can be individually configured as an input or an output under software control. During reset, all bits are configured as input. When used as a divider output or a PPG output, the output latch should be set to "1" and set output mode.	
P17, P16	I/O		
P15 (TC2)	I/O (Input)		Timer/Counter 2 input
P14 ($\overline{PPG}$)	I/O (Output)		Programmable pulse generator output
P13 ($\overline{DVO}$)			Divider output
P12 (INT2 / TC1)	I/O (Input)		External interrupt input 2 or Timer/Counter 1 input
P11 (INT1)			External interrupt input 1
P10 ($\overline{INT0}$)			External interrupt input 0
P23	I/O	4-bit input/output port with latch. When used as an input port, the latch must be set to "1".	
P22 (XTOUT)	I/O (Output)		Resonator connecting pins (32.768 kHz). For inputting external clock, XTIN is used and XTOUT is opened.
P21 (XTIN)	I/O (Input)		
P20 ($\overline{STOP}$ / $\overline{INT5}$)			External interrupt input 5 or STOP mode release signal input
P36 to P30	I/O	7-bit input/output port (high current output) with latch. When used as an input port, the latch must be set to "1".	
P47, P46	I/O	8-bit programmable input/output port (tri-state). Each bit of the port can be individually configured as an input or an output under software control. During reset, all bits are configured as input. When used as a SIO input/output or an UART input/output, the output latch should be set to "1" and set output mode.	
P45 (SO)	I/O (Output)		SIOserial data output
P44 (SI)	I/O (Input)		SIOserial data input
P43 ($\overline{SCK}$)	I/O (I/O)		SIOserial clock input/output
P42	I/O		
P41 (TxD)	I/O (Output)		UARTdata output
P40 (RxD)	I/O (Input)		UARTdata input
P54, P53	I/O	5-bit programmable input/output port (tri-state). Each bit of the port can be individually configured as an input or an output under software control. During reset, all bits are configured as input. When used as timer/counter input, an external interrupt input, or a $\overline{PWM/PDO}$ output, the output latch must be set to "1" and set output mode.	
P52 ($\overline{PWM/PDO}$)	I/O (Output)		8-bit PWM output or 8-bit programmable divider output
P51	I/O		
P50 (INT3/TC3)	I/O (Input)		External interrupt input 3 or Timer/Counter 3 input
P67 (AIN7) to P60 (AIN0)	I/O (Input)	8-bit programmable input/output port (tri-state). Each bit of the port can be individually configured as an input or an output under software control.	A/D converter analog inputs
P77 to P70	I/O	8-bit programmable input/output port (tri-state). Each bit of the port can be individually configured as an input or an output under software control.	
P87(STPR7) to P80(STPR0)	I/O (Input)	8-bit programmable input/output port (tri-state). Each bit of the port can be individually configured as an input or an output or a pull-up resistor under software control.	
P97 to P90	I/O	8-bit programmable input/output port (tri-state). Each bit of the port can be individually configured as an input or an output under software control.	
XIN, XOUT	Input, Output	Resonator connecting pins for high-frequency clock. For inputting external clock, XIN is used and XOUT is opened.	
$\overline{RESET}$	I/O	Reset signal inut or watchdog timer output/address-trap-reset output/system-clock-reset output.	
TEST	Input	Test pn for out-going test. Be tied to low.	
VDD, VSS	Power Supply	+ 5V、 0V (GND)	
VAREF, VASS		Analog reference voltage inputs (High, Low)	

OPERATIONAL DESCRIPTION

1. CPU CORE FUNCTIONS

The CPU core consists of a CPU, a system clock controller, an interrupt controller, and a watchdog timer. This section provides a description of the CPU core, the program memory (ROM), the data memory (RAM), and the reset circuit.

1.1 Memory Address Map

The TLCS-870 Series is capable of addressing 64K bytes of memory. Figure 1-1 shows the memory address maps of the 87CS68. In the TLCS-870 Series, the memory is organized 4 address spaces (ROM, RAM, SFR, and DBR). It uses a memory mapped I/O system, and all I/O registers are mapped in the SFR/DBR address spaces. There are 16 banks of general-purpose registers. The register banks are also assigned to the first 128 bytes of the RAM address space.

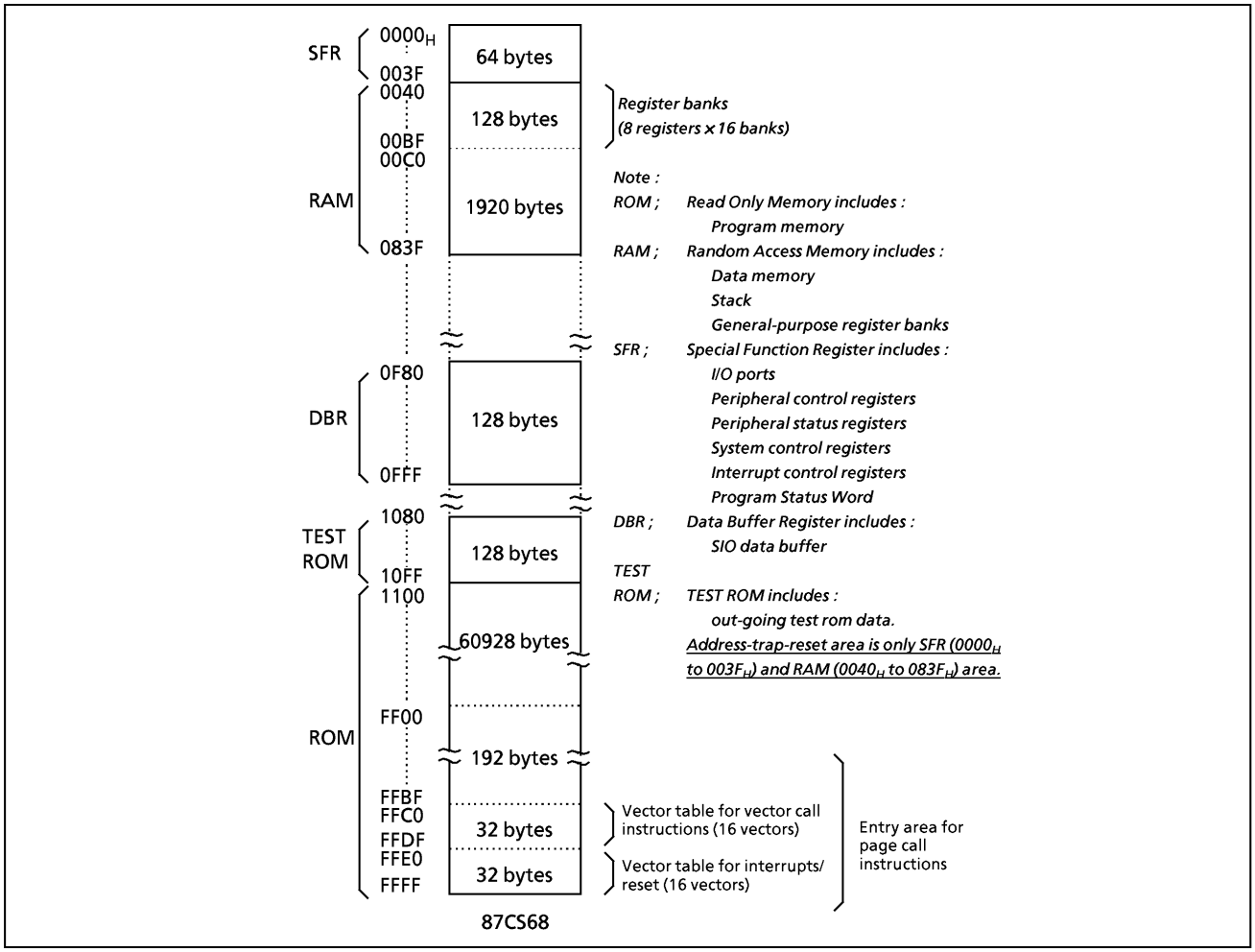


Figure 1-1. Memory Address Maps

Electrical Characteristics

(1) 87CS68

Absolute Maximum Ratings (V_{SS} = 0 V)

Parameter	Symbol	Conditions	Ratings	Unit
Supply Voltage	V_{DD}		– 0.3 to 6.5	V
Input Voltage	V_{IN}		– 0.3 to V_{DD} + 0.3	V
Output Voltage	V_{OUT}		– 0.3 to V_{DD} + 0.3	V
Output Current (Per 1pin)	I_{OUT1}	Ports P0, P1, P2, P4, P5, P6, P7, P8, P9	3.2	mA
	I_{OUT2}	Port P3	30	
Output Current (Total)	ΣI_{OUT1}	Ports P0, P1, P2, P4, P5, P6, P7, P8, P9	160	mA
	ΣI_{OUT2}	Port P3	120	
Power Dissipation [Topr = 70°C]	PD		350	mW
Soldering Temperature (time)	Tsld		260 (10 s)	°C
Storage Temperature	Tstg		– 55 to 125	°C
Operating Temperature	Topr		– 30 to 70	°C

Note: The absolute maximum ratings are rated values which must not be exceeded during operation, even for an instant. Any one of the ratings must not be exceeded. If any absolute maximum rating is exceeded, a device may break down or its performance may be degraded, causing it to catch fire or explode resulting in injury to the user. Thus, when designing products which include this device, ensure that no absolute maximum rating value will ever be exceeded.

Recommended Operating Conditions (V_{SS} = 0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Pins	Conditions		Min		Max	Unit
Supply Voltage	V_{DD}		fc = 8 MHz	NORMAL1, 2 mode	4.5		5.5	V
				IDLE1, 2 mode				
			fc ≦ 4.2 MHz	NORMAL1, 2 mode	2.7			
				IDLE1, 2 mode				
			fs = 32.768 kHz	SLOW mode				
				SLEEP mode				
				STOP mode	2.0			
Input High Voltage	V_{IH1}	Except hysteresis input	V_{DD} ≧ 4.5 V		V_{DD} × 0.70		V_{DD}	V
	V_{IH2}	Hysteresis input			V_{DD} × 0.75			
	V_{IH3}		V_{DD} < 4.5 V		V_{DD} × 0.90			
Input Low Voltage	V_{IL1}	Except hysteresis input	V_{DD} ≧ 4.5 V		0		V_{DD} × 0.30	V
	V_{IL2}	Hysteresis input					V_{DD} × 0.25	
	V_{IL3}		V_{DD} < 4.5 V				V_{DD} × 0.10	
Clock Frequency	fc	XIN, XOUT	V_{DD} = 4.5 to 5.5 V		gear ratio	fc 0.4	8.0	MHz
						fc/2 0.8		
			V_{DD} = 2.7 to 5.5 V			fc/4 1.6	4.19	
						fc/8 3.2		
	fs	XTIN, XTOUT			30.0		34.0	kHz

Note 1: The recommended operating Conditions for a device are operating Conditions under which it can be guaranteed that the device will operate as specified. If the device is used under operating Conditions other than the recommended operating Conditions (supply voltage, operating temperature range, specified AC/DC values etc.), malfunction may occur. Thus, when designing products which include this device, ensure that the recommended operating Conditions for the device are always adhered to.

Note2: Clock frequency fc: The supply voltage range of the Conditions shows the value in NORMAL1, 2 modes and·IDLE 1,2 modes.

D.C. Characteristics

(V_{SS} = 0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Pins	Conditions	Min	Typ.	Max	Unit
Hysteresis Voltage	V_{HS}	Hysteresis input		–	0.9	–	V
Input Current	I_{IN1}	TEST	V_{DD} = 5.5V V_{IN} = 5.5V / 0V	–	–	± 2	μA
	I_{IN2}	Sink open drain port and tri-state port					
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$					
Input Resistance	R_{IN2}	$\overline{RESET}$		100	220	450	kΩ
	R_{IN}	P8 pull-up resistor		30	70	150	
Output Leakage Current	I_{LO}	Sink open drain port and tri-state port	V_{DD} = 5.5V, V_{OUT} = 5.5V	–	–	2	μA
Output High Voltage	V_{OH2}	Tri-state port	V_{DD} = 4.5V, I_{OH} = – 0.7mA	4.1	–	–	V
Output Low Voltage	V_{OL}	Except XOUT and P3	V_{DD} = 4.5V, I_{OL} = 1.6mA	–	–	0.4	V
Output Low Current	I_{OL3}	Port P3	V_{DD} = 4.5V, V_{OL} = 1.0V	–	20	–	mA
Supply Current in NORMAL 1, 2 mode	I_{DD}		V_{DD} = 5.5V V_{IN} = 5.3V/0.2V fc = 8 MHz fs = 32.768 kHz	–	9	12	mA
Supply Currnt in IDLE 1, 2 mode				–	4.5	6.5	
Supply Currnt in NORMAL 1, 2 mode			V_{DD} = 3.0V V_{IN} = 2.8V/0.2V fc = 4.2 MHz fs = 32.768 kHz	–	T.B.D	T.B.D	
Supply Currnt in IDLE 1, 2 mode				–	T.B.D	T.B.D	
Supply Current in SLOW mode	I_{DD}		V_{DD} = 3.0V V_{IN} = 2.8V/0.2V fs = 32.768 kHz	–	30	60	μA
Supply Current in SLEEP mode				–	15	30	μA
Supply Current in STOP mode			V_{DD} = 5.5V V_{IN} = 5.3V/0.2V	–	0.5	10	μA

Note 1: Typical values show those at Topr = 25°C, V_{DD} = 5V.
Note 2: Input current: The current through pull-up or pull-down resistor is not included.

A/D Conversion Characteristics

(V_{SS} = 0V, V_{DD} = 2.7 to 5.5V, Topr = – 30 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}	$V_{AREF} - V_{ASS} \geqq 2.5V$	2.7	—	V_{DD}	V
	V_{ASS}		V_{SS}	—	1.5	
Analog Input Voltage	V_{AIN}	$V_{DD} = V_{AREF}$ = 5.0 V $V_{SS} = V_{ASS}$ = 0.0 V	V_{ASS}	—	V_{AREF}	V
Analog Supply Current	I_{REF}		—	0.5	1.0	V
Nonlinearity Error		V_{DD} = 2.7 to 5.5 V V_{SS} = 0.0 V V_{AREF} = 2.700 V, 5.000 V V_{ASS} = 0.000 V	—	—	± 1	mA
Zero Point Error			—	—	± 1	
Full Scale Error			—	—	± 1	LSB
Total Error			—	—	± 2	

Note: Total Error = total number of each type error excluding guantization error.

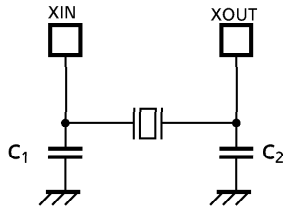
A.C. Characteristics

(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 30 to 70°C)

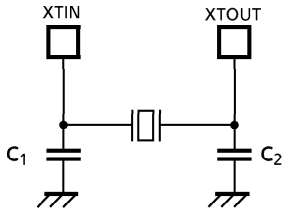
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	t_{cy}	In NORMAL1, 2 mode (gear ratio)	0.5 (1/1)	–	10 (1/8)	μs
		In IDLE1, 2 mode (gear ratio)				
		In SLOW mode	117.6		133.3	
		In SLEEP mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation (XIN input) fc = 8 MHz	50	–	–	ns
Low Level Clock Pulse Width	t_{WCL}					
High Level Clock Pulse Width	t_{WSH}	For external clock operation (XTIN input) fs = 32.768 kHz	14.7	–	–	μs
Low Level Clock Pulse Width	t_{WSL}					

Recommended Oscillating Condition

Parameter	Oscillator	Frequency	Recommended Oscillator		Recommended Condition C_1	Recommended Condition C_2
High-frequency	Ceramic Resonator	8 MHz	KYOCERA	KBR8.0M	30 pF	30 pF
		4 MHz	KYOCERA	KBR4.0MS		
			MURATA	CSA4.00MG		
Low-frequency	Crystal Oscillator	32.768 kHz	NDK	MX-38T	15 pF	15 pF



(1) High-frequency



(2) Low-frequency

Note: When it is used in high electrical field, an electrical shield of the package is recommended to retain normal operations

Note: To obtain an accurate oscillating frequency the condenser capacity must be adjusted on the set.